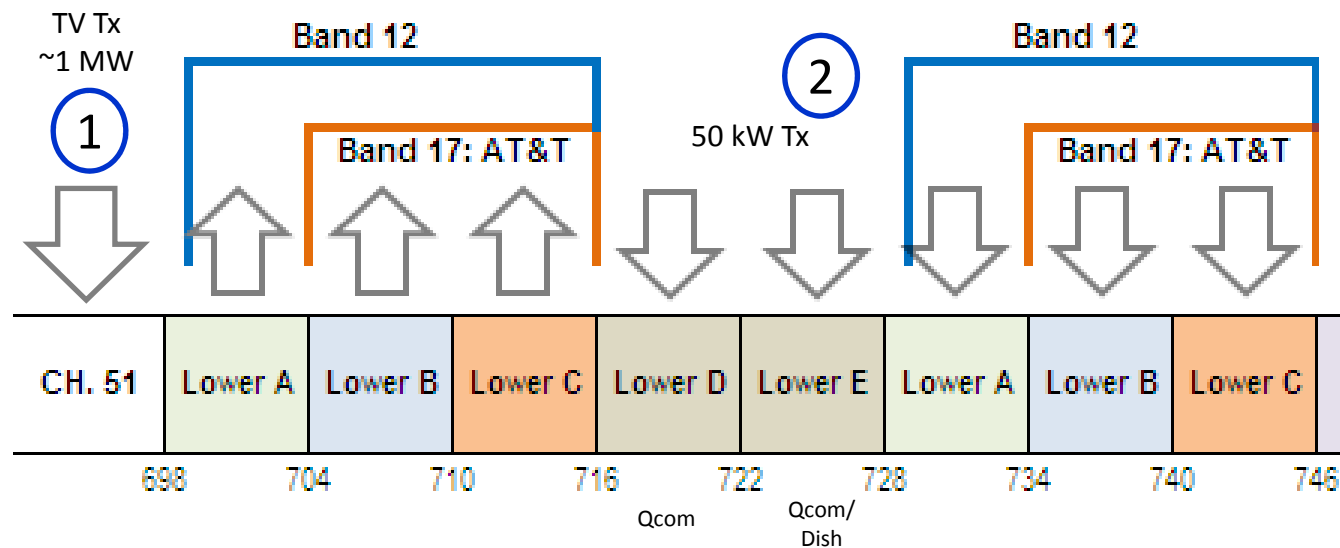


Overview

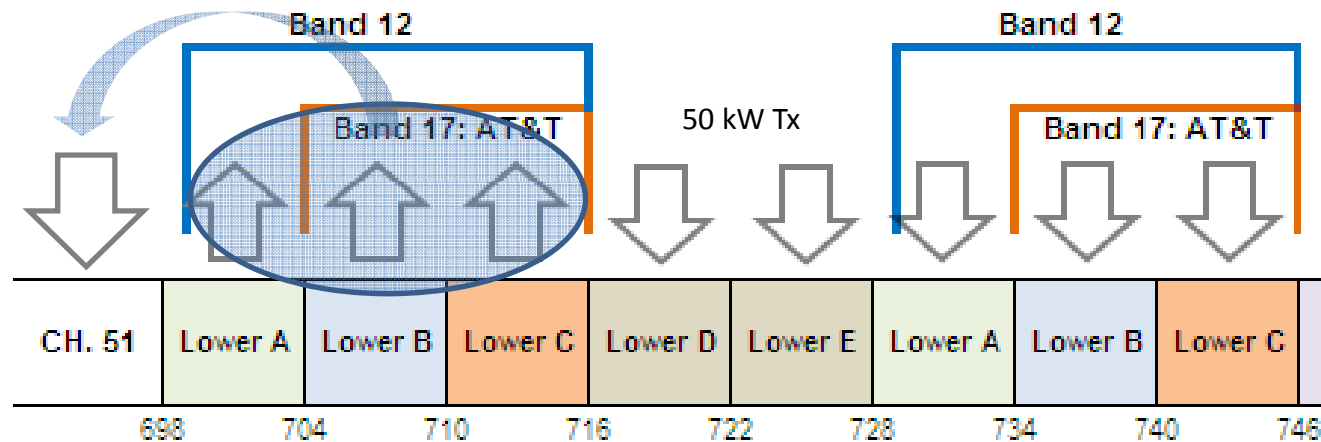
- Lower Band Interference
- Upper Band Interference
- Device Architecture
- AT&T Proposed Acquisition of D/E

700 MHz Lower Band Interference



1. Channel 51 is a high-power television broadcast station, raising potential interference scenarios:
 - Lower A, B and C Block device interference to DTV Ch 51 reception
 - Ch 51 reverse power amplifier intermodulation interference to the Band 12 device's receiver
 - Ch 51 transmissions causing receiver blocking of the Band 12 base stations
2. Lower D and E transmissions interfering with Band 12 Lower A, B, C device receive (729-746 MHz)

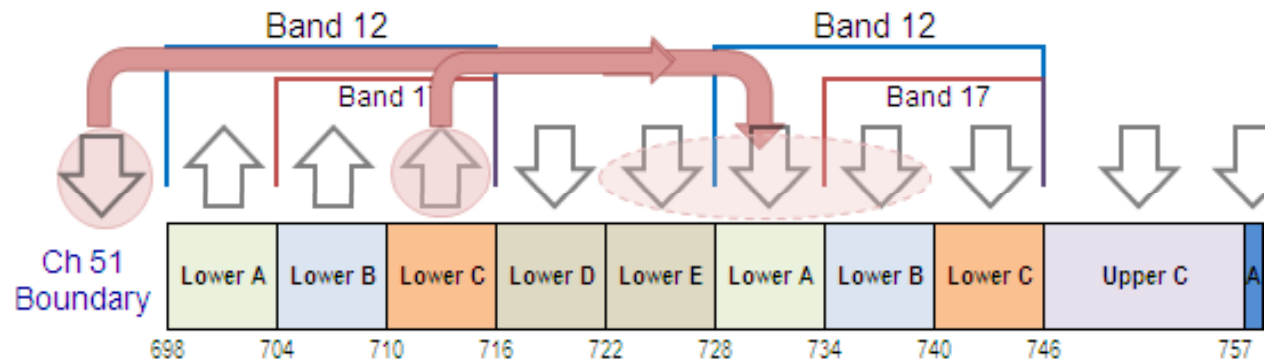
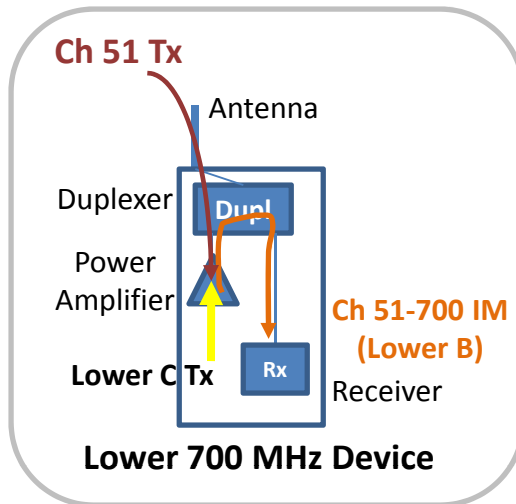
Interference to DTV Receivers



- Two mechanisms might cause 700 MHz device interference to DTV:
 - Out-of-band emissions – Lower 700 MHz devices would emit energy within the Ch 51 receive block
 - DTV receiver may block from a high transmit power in A, B or C
- FCC rules limit OOBE
 - FCC rules limit Lower A, B and C Block emissions into Ch 51
 - LTE emissions mask complies with the rules (both Band 12 and Band 17 devices comply)
- DTV receiver blocking is handled by the DTV filter
 - Lower A Block must meet FCC adjacent channel protection criteria to the Ch 51 coverage contour
 - Lower B and C have no FCC restrictions related to Ch 51 coverage contour
 - Band 12 or 17 transmit filtering has no impact on Ch 51 receiver blocking, only the DTV receiver filter matters

Band 12 devices will not interfere with DTV receivers

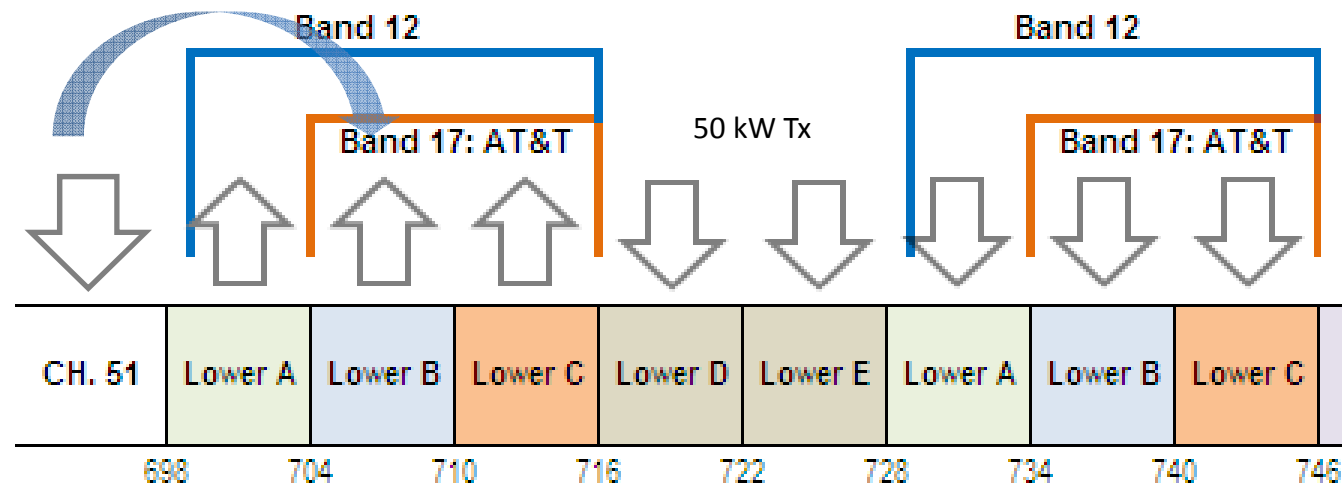
Lower 700 Reverse PA Intermodulation



- Reverse PA intermodulation will not affect the device's own receive blocks
 - A strong Channel 51 signal must mix with a Lower B+C block device transmission at high power over >5 MHz, when device reception is weak within the resource blocks affected by intermodulation products
 - LTE base stations do not allow devices to transmit at full power with >5 MHz bandwidth due to a self-desense issue; and power amplifier linearity improves considerably when not transmitting at full power
 - With <5 MHz Tx bandwidth, any Ch 51-700 intermodulation products would not fall within the device receive blocks (no self-interference issue)
- RF design measures effectively counter any residual concerns
 - If intermodulation is experienced, the LTE system may avoid assigning Tx/Rx resource blocks which form intermodulation pairs to devices transmitting at high power
 - The wireless operator may also deploy an LTE base station several hundred meters away from the Channel 51 station to control device transmit power and provide a stronger downlink desired signal

Band 12 devices will not experience Ch 51-700 intermodulation interference

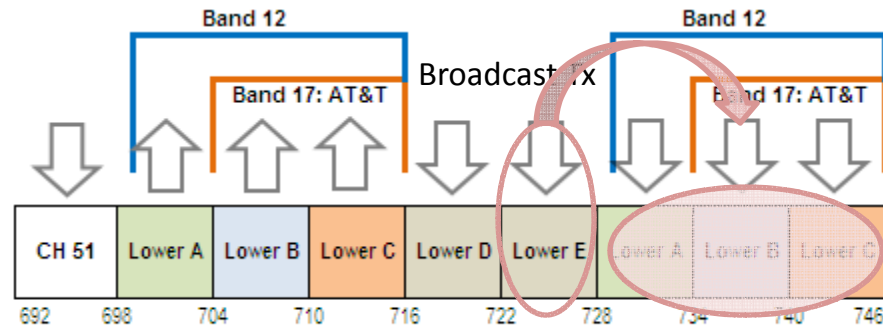
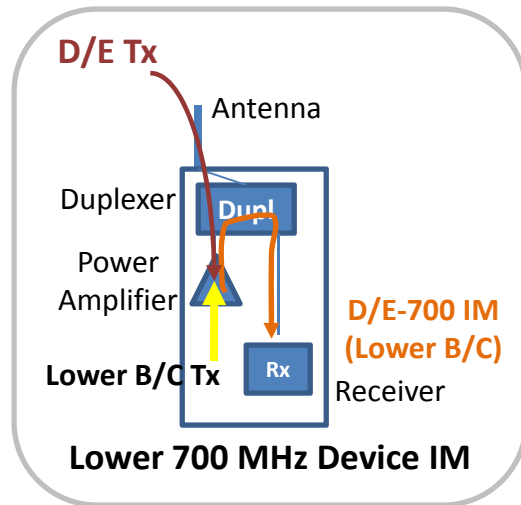
Channel 51 Interference to B12/17 Base Stations



- Channel 51 is a high-power signal
- Lower B and C base stations could employ a filter tailored to B/C to improve Ch 51 rejection
 - With few Channel 51 stations nationwide, this would affect a small fraction of LTE sites
- With a tailored base station filter, interference to B/C base stations is identical for Band 12 or 17

Band 12 base stations may use block-specific filters to fit the licensed spectrum

Lower D and E Broadcast Transmissions



Lower A/B/C Device Receiver Blocking

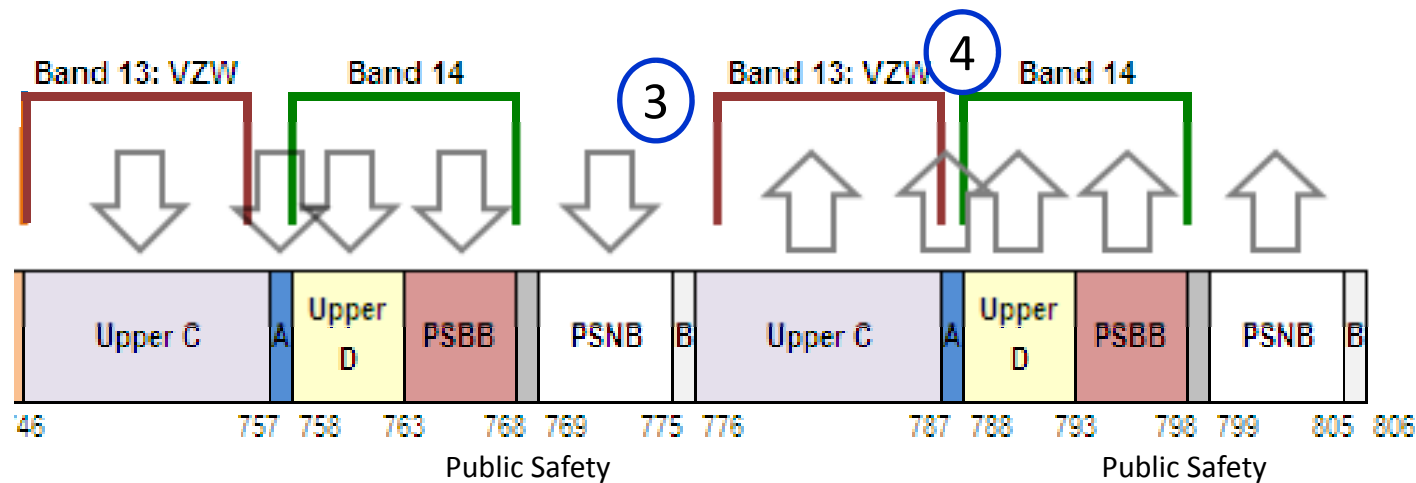
- Lower A/B/C device receiver blocking from strong E Block transmissions
 - Lower D Block does not pose a blocking issue, both B12 and B17 filters have sufficient attenuation
 - Lower E Block is 1 MHz away from Band 12, requiring network engineering to prevent device blocking
- Lower D and E transmissions causing reverse PA intermodulation interference
 - High-power Lower D and E Block signals could enter the device duplexer transmit side, mix with high power B or C transmissions in the power amplifier, and create intermodulation affecting the device's own receive blocks
 - **Interference would affect B12 and B17 devices identically because the filter shape at 716 MHz is identical**
 - Locating a Lower B/C Block base station near the Lower D or E Block transmitter would increase the desired signal strength, overcoming any intermodulation interference concerns
- Coordinating site locations of B/C base stations and D/E transmitters would solve both intermodulation and blocking concerns and enable use of a Band 12 device duplexer for all Lower 700 devices

Devices may use Band 12 duplexers

Overview

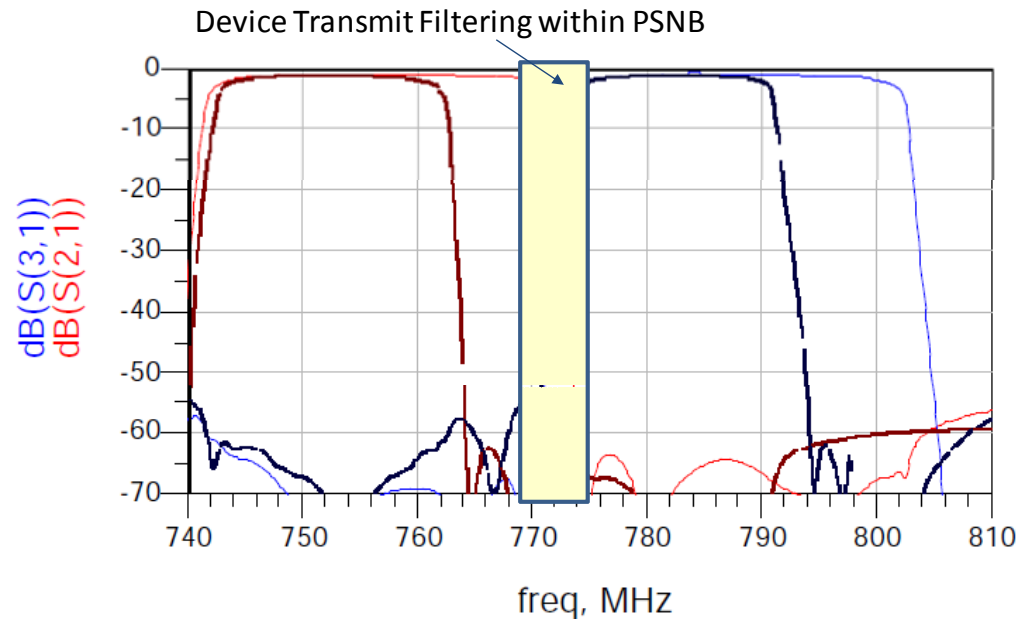
- Lower Band Interference
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700 MHz Upper Band Interference



3. LTE device emissions into Public Safety Narrowband (PSNB) device receive spectrum
4. LTE device second harmonic transmission may interfere with GPS reception in the same device

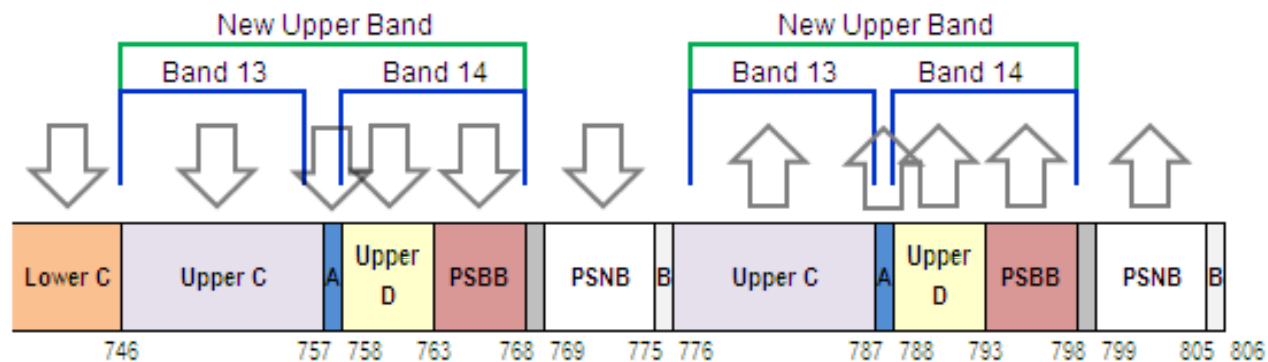
Emissions Protection to PSNB



- Avago Technologies simulations of Band 13 and Full Upper Band duplexers show similar filter performance within the PSNB device receive block
 - The filter edge at 777 MHz is the same for both Band 13 and the Full Upper Band duplexers
 - The larger passband of the Full Upper Band does not significantly alter the filter attenuation within PSNB
- The FCC rules for PSNB protection are met through the 3GPP LTE device emissions mask*, ***which is not dependent on the duplexer filtering***

Upper Band 2nd Harmonic Interference

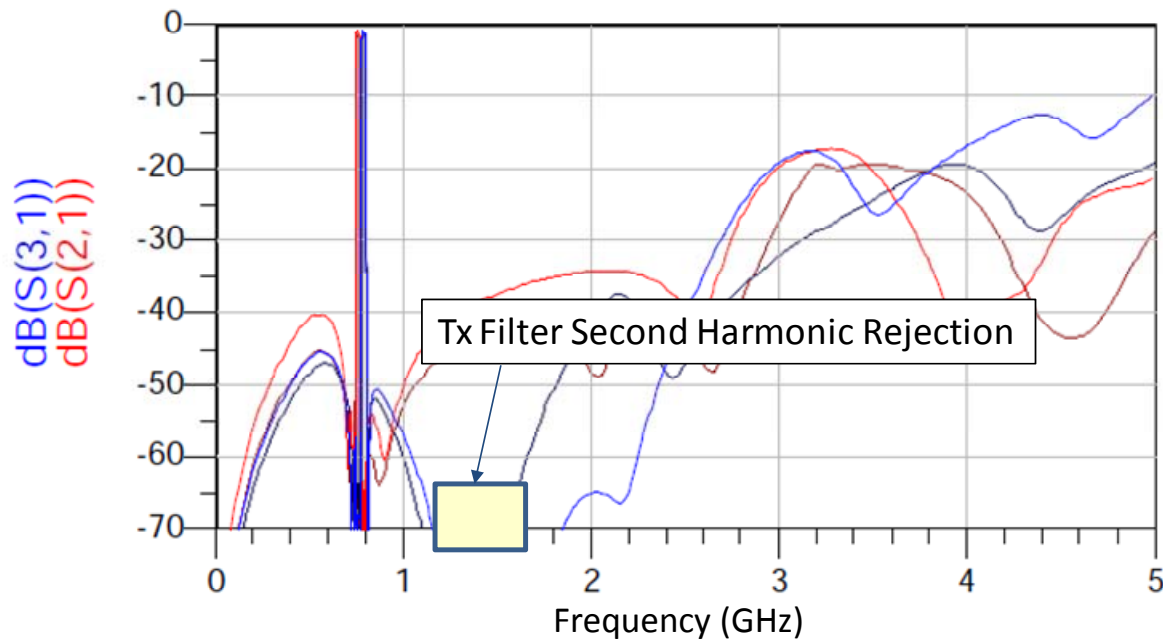
- A transmitter produces harmonics at multiples of the transmitted frequency
- The second harmonic of 787.21-788.21 MHz falls within the GPS receive bandwidth; strong transmissions within this range may interfere with device GPS reception
- None of the currently proposed 700 MHz LTE channels would actively transmit in this frequency range – the Upper D Block is closest, but the transmission bandwidth of LTE does not intrude below the 788.21 MHz boundary



- The Band 13 filter is immediately adjacent to 787-788 MHz, providing no attenuation to the frequencies of concern
- The Full Upper Band duplexer would include 787-788 MHz in the device transmit passband, but filter performance for Band 13 and 14 are identical to that of the Full Upper Band given the spectral proximity

Upper Band 2nd Harmonic Interference

- The second harmonic issue is mitigated by duplexer rejection of the second harmonic frequencies as shown in the Avago Technologies graph, which indicates similar performance for both Band 13 and Full Upper Band duplexers:



Upper 700 MHz paired broadband blocks could use a single duplexer

700 MHz Interoperability Conclusions

- Lower 700 MHz Band devices should use Band 12
 - Channel 51 intermodulation interference to Lower B and C will not occur given LTE uplink transmission bandwidth limitations
 - Lower D and E Blocks pose an intermodulation interference risk to both Band 17 and Band 12 devices which could be handled through LTE base station coordination
 - This coordination would simultaneously fix the Band 12 receiver blocking concern
 - Band 12 and Band 17 3GPP specifications are identical except for the tighter D/E blocking specification, which is unnecessary for the above reasons
- Upper 700 MHz Band devices should use a single band class encompassing Bands 13 and 14
 - PSNB protection criteria are met through the device emissions mask, not the duplexer filtering
 - GPS harmonics issue is well handled through device design and duplexer harmonic filtering, smaller duplexer passbands provide no additional attenuation to 787-788 MHz

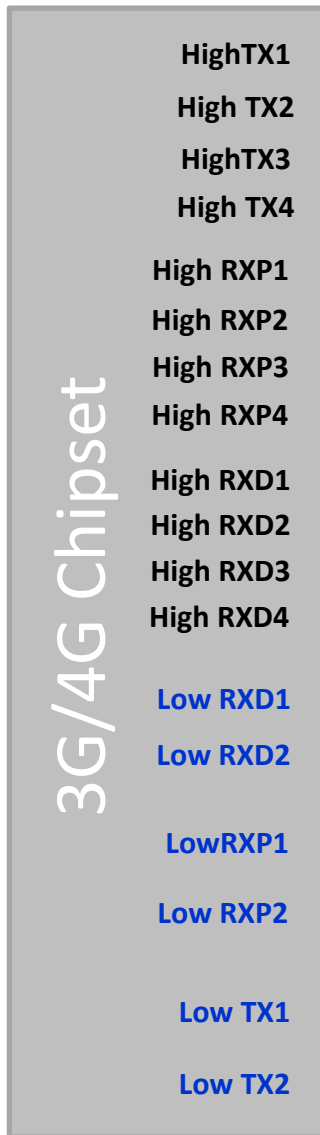
Overview

- Lower Band Interference
- Upper Band Interference
- Device Architecture
- AT&T Proposed Acquisition of D/E

Device Architecture

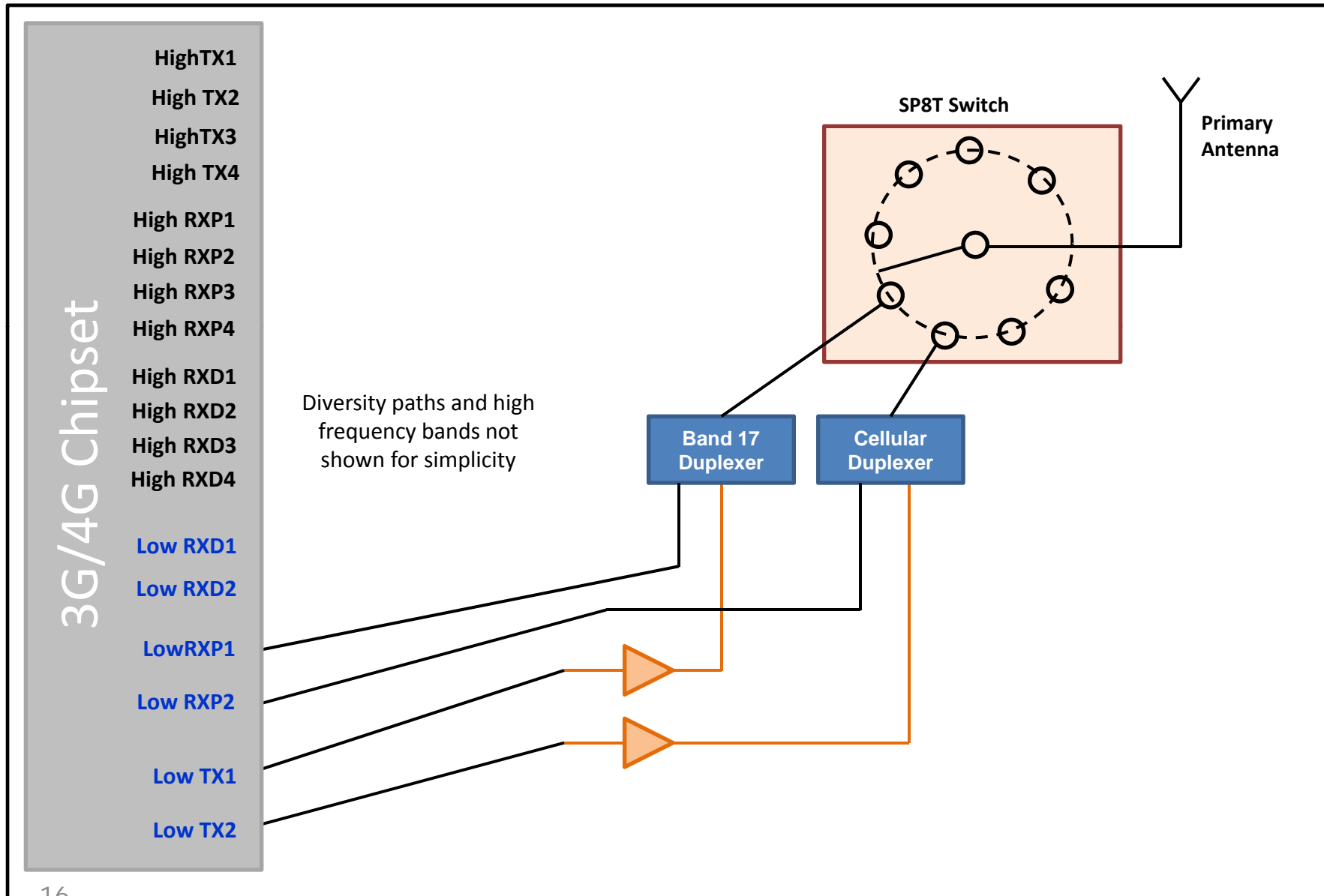
- The record well documents the issues of limited band support – space and power are limited, and multiple bands increase the device size and cost
- Current 3G/4G device chipsets support several high frequency bands, but only two low frequency bands
- Achieving 700 MHz interoperability requires broader device duplexers to make the best use of the chipset's limited low-frequency band ports
 - Lower 700 MHz interoperability across Lower A, B, and C Blocks may be achieved by replacing the Band 17 device duplexer with a Band 12 duplexer
 - Upper 700 MHz interoperability across Upper C, D and PSBB paired blocks may be achieved by replacing Band 13 device duplexers with the Full Upper Band duplexer covering 746-768 MHz UE Rx, 777-798 MHz UE Tx

Sample 3G/4G Chipset Band Support

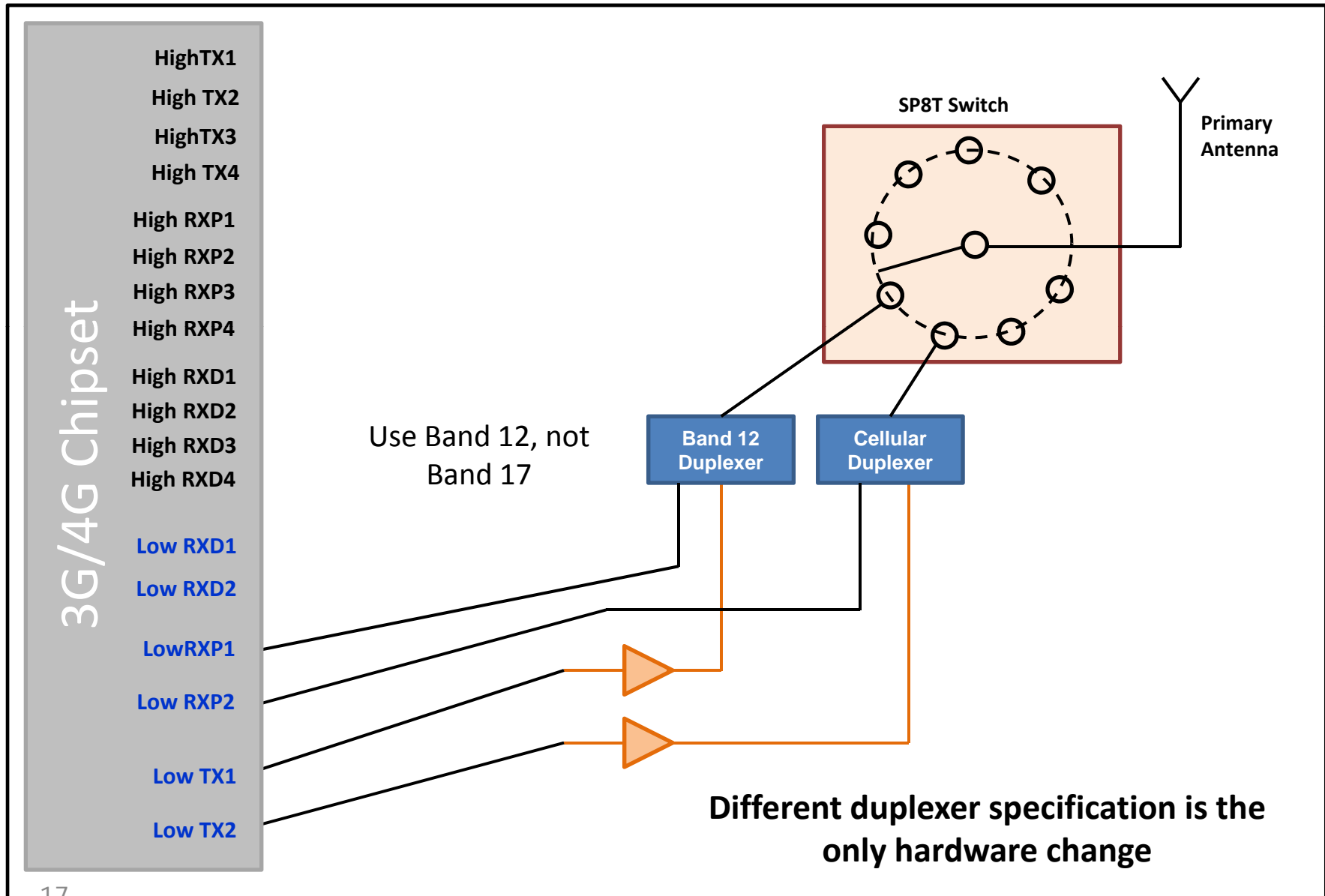


- The leading 3G/4G device chipset will support a limited number of frequency bands
- The chipset provides transmit and receive ports, each capable of handling a relatively wide frequency range
 - High frequency means > 1 GHz
 - Low frequency means < 1 GHz
- Fewer low frequency bands may be supported because of size – lower frequency components are physically larger
- Transmit ports provide uplink signals denoted by Tx#
- Receive ports process the downlink signals
 - RXP# denotes a primary receive path, attached to the main antenna used for both transmit and receive
 - RXD# denotes a diversity receive-only path, attached to a secondary, internal antenna

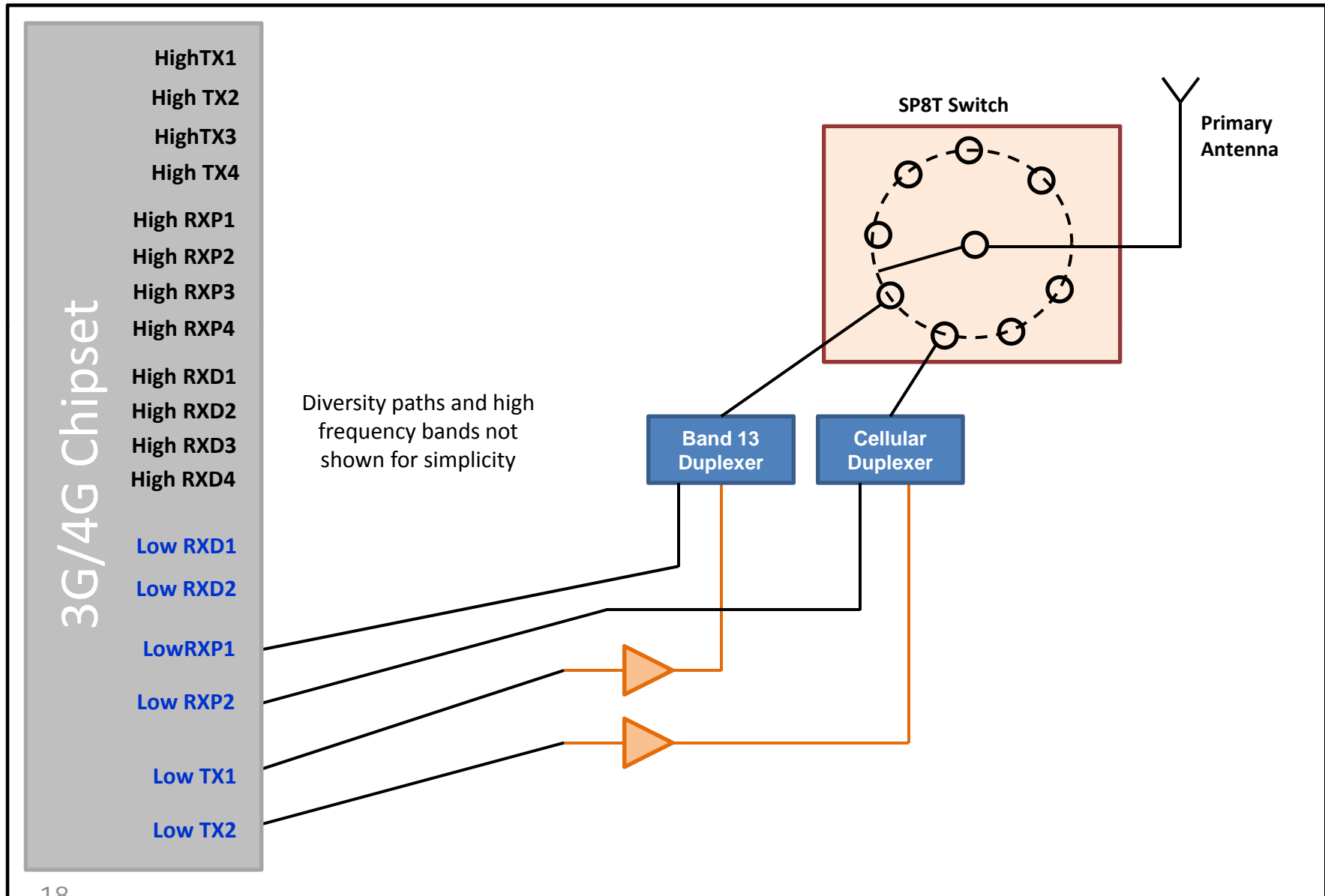
AT&T Device Design for Low Frequency Bands



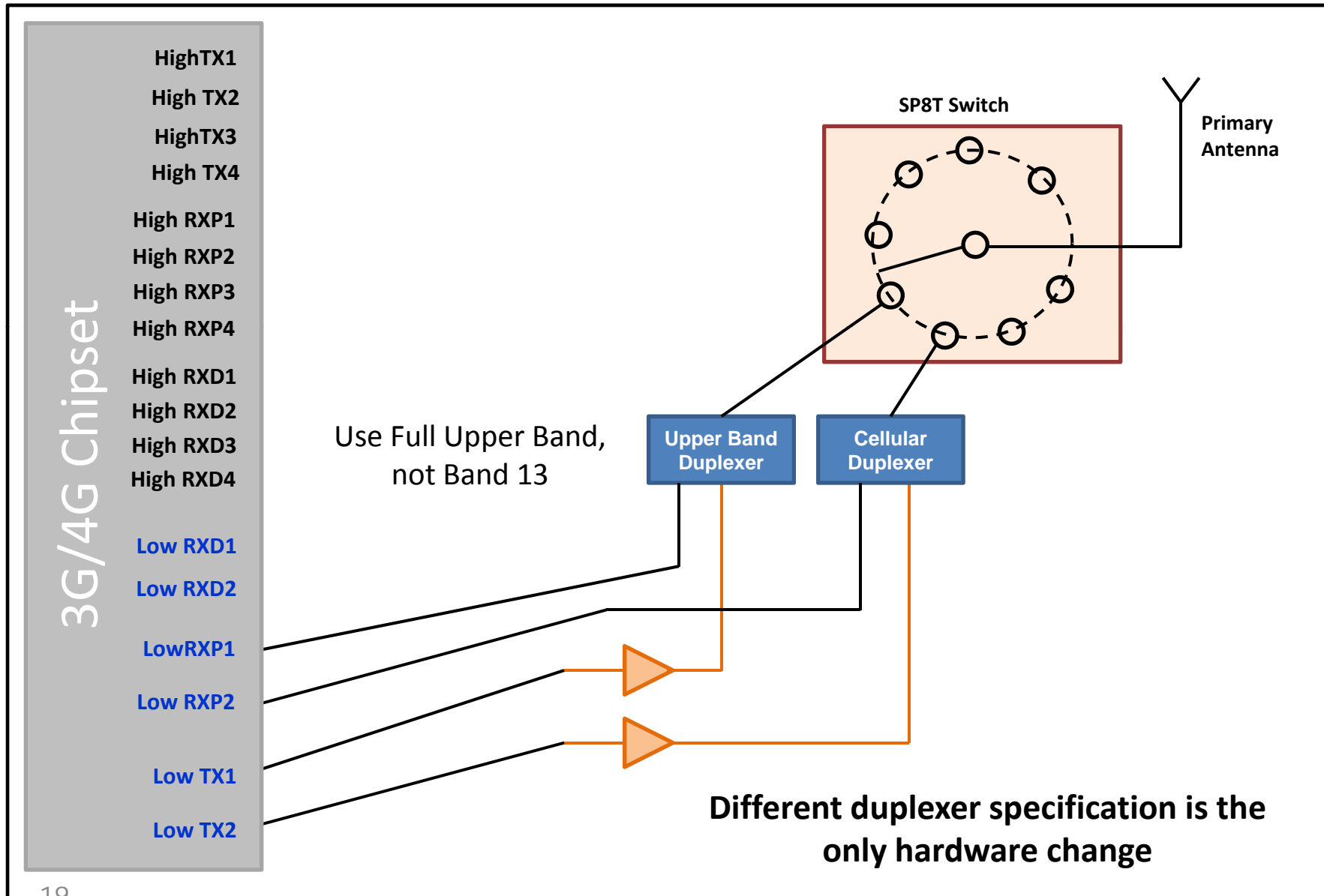
Lower 700 MHz Interoperable Device Design



VZW Device Design for Low Frequency Bands



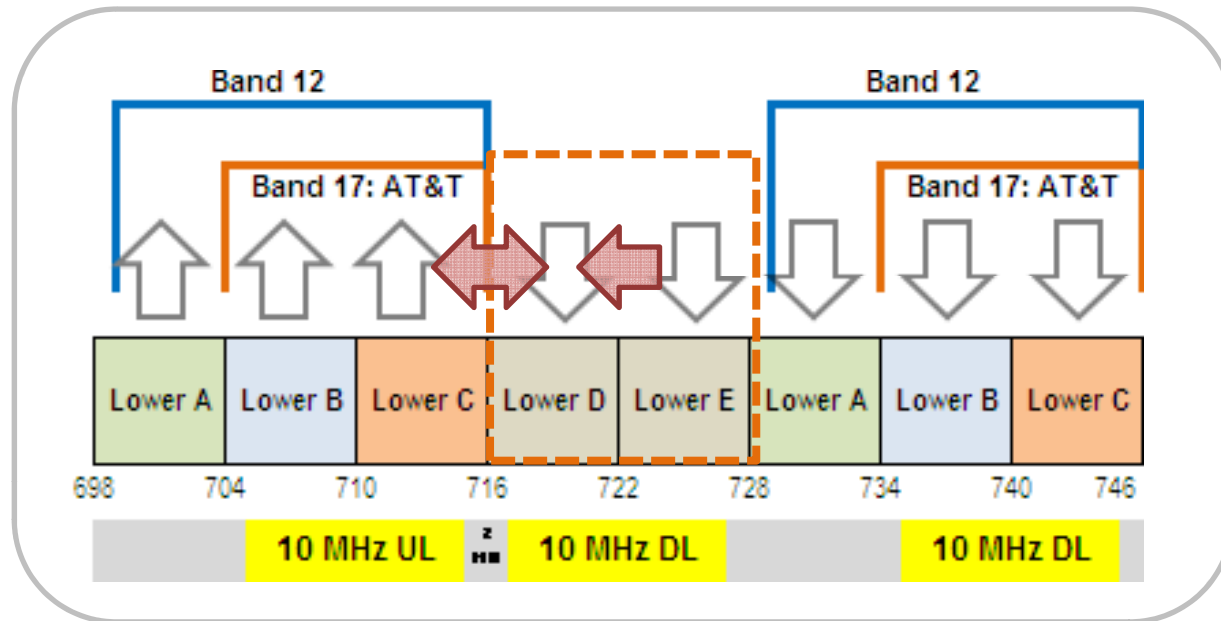
Upper 700 MHz Interoperable Device Design



Overview

- Lower Band Interference
- Upper Band Interference
- Device Architecture
- AT&T Proposed Acquisition of D/E

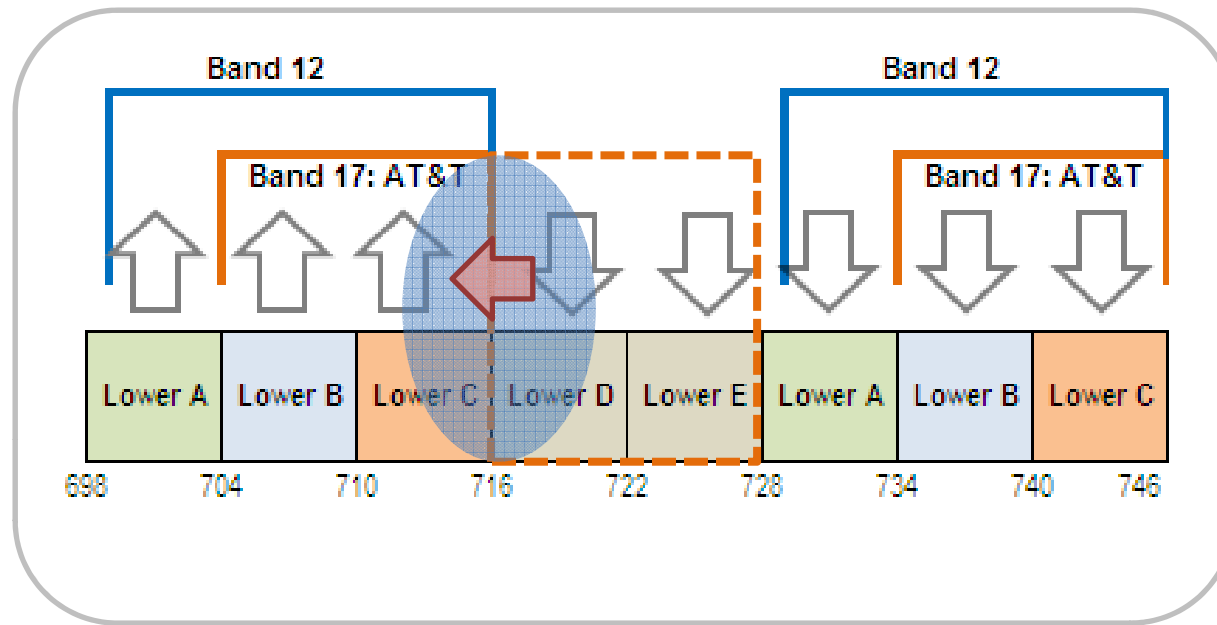
AT&T's 700 MHz Dilemma



- AT&T's proposed purchase of Lower D and E brings new device interference issues
 - AT&T cannot use D&E and B&C in the same device at the same time – B/C transmit would interfere with D/E receive (at best, 2 MHz of separation)
 - AT&T device reception in D Block may be impacted by high-power E Block base stations, the same receiver blocking issue AT&T cited in forming Band 17
- AT&T intends* to use the Lower D and E Blocks as supplemental downlink LTE carriers, paired with AWS or cellular uplink spectrum
 - This solves the device self-interference issue – the device does not need to receive D/E while simultaneously transmitting in Lower B/C
 - But this requires two device receiver bands, one for D/E receive (new), and one for B/C (such as Band 12)

*Kristin Rinne (AT&T) testimony to the FCC, January 12, 2011

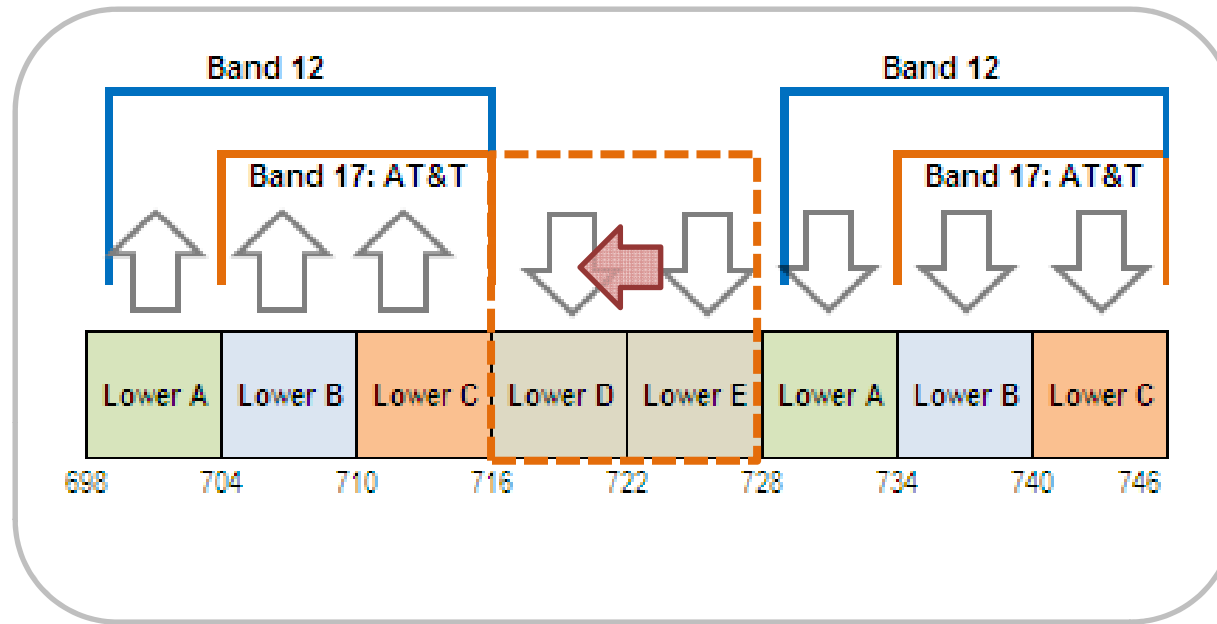
AT&T Threat to C Block Uplink Reception



- When D/E was used as MediaFLO, the spectrum was employed at high power at one or two locations in a city – a simple coordination process
- AT&T is likely to use D/E at thousands of locations nationwide, a very difficult coordination process
- Lower C base stations built close to a D/E transmitter will receive interference because of the close spectral proximity of the base station transmission

AT&T's plan for Lower D/E poses a serious threat to C Block uplink performance

New AT&T Band Affirms No E Block Concerns



- The new AT&T device receiver band covering Lower D and E would receive the high-power E Block transmissions in-band with no filtering (red arrow)
- AT&T's plans imply that Dish E Block transmissions will not cause blocking of the new D/E receiver – or, coordination would effectively protect the D/E receiver
- Therefore, Band 12, which provides modest E Block filtering superior to that of the new D/E receiver, must also meet AT&T's performance standards

All Lower 700 MHz FDD devices should be using Band 12